CLAIMS

What is claimed is:

1. A method of making a multi-layer ferroelectric thin film composite which comprises:

(A.) depositing onto a substrate a first precursor composition for a first dielectric thin film layer and heating for a time sufficient to render a first dielectric thin film layer ; and

(B.) depositing onto the first dielectric thin film layer a second precursor composition for a second thin film layer comprising an organic solvent, a polymeric heterocyclic amide and organometallic compound and heating for a time sufficient to render a porous thin film layer, wherein the amount of porosity of the porous thin layer is dependent upon the ratio of organometallic compound to polymeric heterocyclic amide in the second precursor composition; and

(C.) annealing the product of step (B.).

2. The method of Claim 1, further comprising, prior to depositing the first precursor composition onto the substrate, depositing onto the substrate a buffer precursor composition comprising an organic solvent and organic metallic compounds, and then heating to obtain a composite of a buffer layer and substrate.

3. The method of Claim 2, wherein the thickness of the buffer layer is up to 300 nm.

4. The method of Claim 2 or 3, wherein the buffer layer further comprises a polymeric heterocyclic amide.

5. The method of Claim 1, wherein the product of step (C.) is annealed at a temperature between from about 550° C to about 750° C.

6. The method of Claim 1, wherein the first dielectric thin film layer has a thickness between from about 50 to about 900 nm.

7. The method of Claim 6, wherein the second thin film layer has a thickness between from about 40 to about 300 nm.

8. The method of Claim 1, wherein the porosity of the second thin film layer is controlled by the molar ratio of metal:polyvinylpyrrolidone.

9. The method of Claim 1, wherein some of the elements in the first dielectric thin film layer and second thin film layer are the same.

10. The method of Claim 1, wherein the first dielectric thin film layer and/or second thin film layer is selected from the group consisting of a lead lanthanide titanate, lead titanate, lead zirconate, lead magnesium niobate, barium titanate, lead lanthanum zirconate titanate, lead zirconate titanate, barium strontium titanate, lanthanum-modified lead zirconate titanate, bismuth zinc niobate and bismuth strontium tantalite.

11. The method of Claim 10, wherein the first dielectric thin film layer and/or second thin film layer comprises lead zirconate titanate, barium strontium titanate, lanthanum-modified lead zirconate titanate, bismuth zinc niobate and/or bismuth strontium tantalite.

12. The method of Claim 11, wherein the first dielectric thin film layer and/or second thin film layer are of the formula $(Ba_{1-x}Sr_x)TiO_3$, $PbZr_{1-x}Ti_xO_3$ or $Pb_y La_z (Zr_{1-x}Ti_x)O_3$ wherein x is between from about 0.1 to about 0.9, y is from about 0.95 to about 1.25 and z is between from about 0 to about 0.15.

13. The method of Claim 12, wherein x is between from about 0.30 to about 0.70.

14. The method of Claim 11, wherein the first dielectric thin film layer and/or second thin film layer are of the formula $Bi_{3x}Zn_{2(1-x)}Nb_{2-x}O_7$ wherein x is between from about 0.40 to about 0.75.

15. The method of Claim 11, wherein the first dielectric thin film layer and/or second thin film layer are of the formula $Sr_xBi_yTa_2O_{5+x+3y/2}$ wherein x is between from about 0.50 to about 1.0 and y is between from about 1.9 to about 2.5.

16. The method of Claim 1, wherein the substrate is selected from the group consisting of a semiconductor, glass or a metallic foil.

17. The method of Claim 16, wherein the semiconductor contains a Group 12 – 16 metal and the metallic foil is selected from the group consisting of aluminum, brass, nickel alloy, nickel-coated copper, platinum, titanium and stainless steel foil.

18. The method of Claim 1, wherein the first dielectric thin film layer is composed of several dielectric layers in a regular or irregular superlattice structure.

19. The method of Claim 1, wherein at least one of the first dielectric thin film layer or second thin film layer is formed by the deposition of a composition containing polyethylene glycol.

20. The method of Claim 1, further comprising forming a relatively thin electrode layer on top of the porous layer.

21. The method of Claim 20, wherein the electrode layer comprises Ni, Cu, Au, Ag or Pd.

22. A method of making a multi-layer ferroelectric thin film composite which comprises:

(A.) depositing onto a substrate a precursor composition for a buffer layer and heating until forming a buffer layer having a thickness between from about 0 to about 300 nm;

(B.) depositing onto the buffer layer a second precursor composition for a first dielectric thin film layer and heating until a dielectric thin film layer having a thickness of from about 50 to about 900 nm is formed, the thickness of the first dielectric thin film layer being greater than the thickness of the buffer layer; and

(C.) depositing onto the first thin film layer a third precursor composition containing polyvinylpyrrolidone for a second thin film layer and heating until a porous thin film layer having a thickness of from about 40 to about 300 nm is formed; and

(D.) annealing the product of step (C.) at a temperature between from about 550° C to about 750° C.

23. A method of making a multi-layer, thin film composite which comprises:

(A.) sol-gel depositing onto a substrate a precursor composition for a buffer layer, the precursor composition comprising an organic solvent and organic metallic compounds;

(B.) heating the product of step (A.) to render a composite of a buffer layer and substrate;

(C.) sol-gel depositing onto the product of step (B.) a precursor composition for a first thin film layer comprising an organic solvent and organometallic compounds;

(D.) heating the product of step (C.) to render a composite wherein the buffer layer is between the substrate and the first thin film layer and wherein the thickness of the first thin film layer is greater than the thickness of the buffer layer;

(E.) sol-gel depositing onto the product of step (D.) a precursor composition for a second thin film layer comprising an organic solvent, a polymeric heterocyclic amide and organometallic compounds;

(F.) heating the product of step (E.) to render a composite wherein the first thin film layer is between the buffer layer and the second thin film layer and further wherein the second thin film layer is porous; and

(G.) annealing the product of step (F.).

24. The method of either Claim 22 or 23, wherein the polymeric heterocyclic amide is polyvinylpyrrolidone.

25. The method of either Claim 22 or 23, wherein the buffer layer of step (B.) has a thickness from 0 to about 300 nm.

26. A ferroelectric thin film capacitor, memory device, pyroelectric sensor device, wave guide modulator or acoustic sensor containing the multi-layer thin film composite of any of Claims 1 to 25.

27. The method of Claim 23, wherein some of the elements in the buffer layer, first dielectric thin film layer, and second thin film layer are the same.